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PLANNING AND FINANCING STORM SEWERS

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The planning and financing of storm drainage systems are in most respects among the most difficult projects a city ever will undertake. Storm sewers comprise a utility-type service to real property that does not lend itself to special assessment financing because the allocation of benefit is difficult and even controversial.

Planning and financing storm sewers through new subdivisions are difficult because the natural drainage area seldom coincides with the subdivision area. Who is to pay for the storm sewer capacity above that required for the immediate needs of the subdivision?

In addition to the problem of financing, storm sewers present another area of doubt in that some decision must be made as to the extent and type of system to be installed. A system of storm sewers that would serve an area under all foreseeable conditions of rainfall, runoff, and flooding would be prohibitively expensive. As a practical matter it is cheaper to have an occasional flood that exceeds the storm drain capacity, with minor property damage and a substantially lower investment in the storm sewer system. On the other hand, no storm sewers at all can mean extensive property damage in occasional periods of heavy rainfall together with enough accumulation of polluted water to constitute a public health hazard. As a practical matter, the storm drainage system should be built to provide a reasonable (but not perfect) degree of protection against all rainfalls.

Topographic conditions are particularly important in creating a storm drainage problem in many areas. In a partly or fully developed area with considerable slope, the property owners at the top of the area are not even inconvenienced by heavy and prolonged rain. Others farther down the slope may have occasional minor flooding, while the relatively few property owners at the bottom of the area may live in homes that are subject to severe damage from heavy rainfalls. It is no simple matter to convince the property owners farther up the slope of the need for a storm drainage system. They can see no reason why they should pay anything at all for storm drains that will benefit properties farther down the slope.

Another difficulty in storm drainage is that the most acute problems occur in the outlying residential areas surrounding many cities in all parts of the United States and Canada. Too often subdivisions have been built to inadequate or nonexisting standards for public facilities and improvements, especially storm drainage. The first heavy rainfall results in water backing into basements and even pouring through the windows. Everybody is in favor of doing something about it until tentative cost figures are brought forth. Then the enthusiasm quickly dies down.

The storm drainage problem is much more acute in residential areas than it was before the second world war because of the great increase in residential home building in the fringe areas of cities. Formerly the undeveloped land would absorb a great deal of rainfall and provide for drainage through natural drainage channels and infiltration to the water table. In some areas low-lying swamp lands served as natural reservoirs until drainage channels could carry off the excess runoff water from rainfall. Housing development has brought this land into intensive urban use with streets, driveways, sidewalks, and buildings that prevent percolation into the ground and provide faster and

greatly increased runoff of storm water. Many natural drainage channels now are unavailable or inadequate. In some cases residential development has meant the filling in of swamp areas and restricting natural drainage channels to reclaim land for residential development. This accordingly has reduced the natural facilities for absorption and runoff of water.

Storm sewers are a type of improvement that does not necessarily have to be built, as contrasted with water lines and sanitary sewer facilities. In addition, for various engineering reasons, storm sewers need not be built in every area of the city if natural surface drainage is available. The need for storm sewers is conditioned by topography; climatic conditions, especially rainfall; soil types; and the extent to which residential areas are built up.

Having stated the problem, what can be done about it? It is the purpose of this report to suggest the planning and financial approaches to storm drainage with particular attention to assignment of responsibility and the methods of financing. Subsequent sections of this report discuss the responsibility of the city government in planning and land subdivision; governmental organization; and methods of financing.

Planning for Storm Drainage

A practical dilemma in planning a storm sewer system for a drainage area is that it has to be done in reverse If main trunk lines could be installed last — after an area is fully built up and the necessary local and collector drains installed — there would be little doubt about size, design, location, or financing. In practice, however, the trunks must be in place to receive the discharge from a local system when it is completed? Otherwise damage to downstream properties inevitably will occur.

Furthermore, because of the lack of storm drainage (together with lack of sanitary sewerage), development in otherwise desirable areas may actually be deterred. It is estimated, for example, that the current plan to provide storm drainage facilities in a portion of western Tacoma will permit development of about 1,500 acres for residential purposes.

Because storm drainage is essentially a matter of coping with the excesses of nature the scene of the crime may logically be taken as a starting point.

The Drainage Area Concept. "Watershed"[1] is a term that appears frequently in storm drainage studies. Often it is used interchangeably with "drainage area" or "drainage basin." The watershed of a river is composed of the many smaller watersheds of its tributaries. Figuring especially in the planning and financing of storm sewers in new subdivisions are the drainage areas of these small headwaters and streams.

To illustrate the reasonableness of the drainage area approach to planning for storm sewers, a small watershed may be examined before and after land development. Before development it functioned normally in the hydrologic cycle. When water struck the surface of the land it was *absorbed* and held by the surface soil. And when the water content of this layer reached a certain point, depending on soil conditions, any surplus penetrated by gravity (*infiltration*) to underground strata of soil, gravel, or porous rock where it was stored as *ground water*. (The surface of this underground reservoir is called the *water table*.)

When the rate of precipitation is greater than the rate of absorption and infiltration, part of the water runs along the surface of the ground directly into creeks and rivers and thence into lakes and oceans. This is called *surface runoff*.

But after development, when man has substituted roofs, sidewalks, parking lots, and paved streets for soil, grass, and trees, he has sealed off the pervious surfaces and upset the hydrologic cycle as it formerly operated in that small watershed Much of the water that normally would have been absorbed and infiltrated into the ground runs off the surface instead. As a result, volume and

[1]Derived from the German word *wasserscheide*, current since the 14th century, meaning, literally, "water-parting." In dictionaries it retains this meaning, which, in America is also conveyed by the noun "divide." The looser meaning — the land area that contributes to the flow of a stream — has become the more common one.

rate of surface runoff are increased by several hundred times. And man must then build curbs and gutters, storm drains, retention basins, and other structures to protect himself from the consequences of his own actions. Thus storm drains are little more than devices designed to compensate for the upset of a balanced natural process.

The impact of urban development on the hydrologic cycle and the consequences for storm sewer construction can be described in different ways. A graphic demonstration is Table 1, taken from the unpublished *Report to Westchester County Board of Supervisors on Storm Water Control* (1945) by James C. Harding, commissioner of public works. It shows the theoretical amounts of storm water discharged from one square mile of a particular drainage area under various degrees of intensity of development.

Table 1

Theoretical Storm Water Discharge by Types of Development*
(Area: one square mile)

Type of development	Description	Peak discharge (gallons/minute)	Required pipe size
Wooded	Normal forest growth	30,000	36"
Rural	50% forest; 50% farm	50,000	48"
Suburban	40% wooded; 40% lawn and garden; 20% roof and pavement	140,000	72"
Urban	50% lawn and garden 50% roof and pavement	360,000	102"

*Assumptions: No ponding; moderate surface slope (generally 3%); pipe slope 6" per 100'; 10-year frequency storm in Westchester.

Engineering Considerations. Storm drains are designed to carry away peak flows of storm water that occur at a specified frequency. The most common method of determining peak flow is the "rational method" described by the equation $Q = CiA$ where:

Q is the rate of runoff in cubic feet per second,
C is the coefficient of runoff and equals runoff rainfall,
i is the intensity of rainfall in inches per hour,
A is the drainage area in acres,
(iA is the rainfall in cubic feet per second).[2]

The term design frequency defines the recurrence interval during which a given facility will be called upon to carry a storm flow equal to or in excess of its capacity. At this frequency, local flooding may occur. In the event of a prolonged, high intensity rainfall that exceeds the intensity for the design frequency, general flooding occurs.

Despite the apparent simplicity of the rational method, the engineer may be called upon to exercise considerable discretion. Being dependent on surface conditions, the runoff coefficient is most affected by urban development. In general, according to C. Smallwood, Jr., associate professor in the civil engineering department of North Carolina State College, in an unpublished paper, "Rational Method of Estimating Storm-Water Runoff in Sewerage Design," the main variables affecting it are the degree of perviousness of the area and the length of time from the beginning of the storm.

[2]The unconventional mixing of units in this formula is possible because one inch of rainfall per hour on one acre at 100 per cent runoff is equivalent to 1.008 cubic feet per second.

. . . thorough wetting of the area, such as occurs in prolonged rain storms increases the magnitude of "C." Thus at the beginning of a storm on a sandy area practically none of the water will reach the sewer. Even after several hours, perhaps only half would appear at a given inlet. On the other hand, the proportion of the rainfall reaching an inlet from a concrete surface, rapidly approaches 100 per cent. Mixed surfaces will be somewhere between these extremes.

It is standard subdivision design practice to calculate runoff from the surface of the new development, as finally built up, and to design the needed local storm drainage structures accordingly. By using assumed values of C established for different types of surfaces, which are available in engineering texts, the value of Q (rate of runoff in cubic feet per second) for any given subdivision can be determined with some degree of accuracy.

Table 2 below was prepared by the San Antonio Department of Public Works for use in calculating storm water runoff from new developments. (Coefficients have been converted to percentages.)

Table 2

Per Cent of Storm Water Runoff by Types of Development*

	Average slope			
Character of area	Up to 1%	1 to 3%	3 to 5%	Over 5%
Businesses or commercial area (90% or more impervious)	95	96	97	97
Densely developed area (80 to 90% impervious)	85	88	91	95
Closely built residential area	75	77	80	84
Undeveloped area	68	70	72	75
Average residential area	65	67	69	72

*In all cases, wet antecedent conditions shall be assumed. Runoff rates shall be computed on the basis of ultimate development of the entire watershed contributing runoff water to the proposed subdivision. For determination of time of concentration, velocities shall be assumed on the basis of concrete lined channels and streets carrying storm waters in the contributing watershed area. Rainfall intensities shall be obtained from Figure X [a graph showing the value of i for various durations and frequencies].

However, what can be determined for a subdivision of limited geographical extent may be less predictable for an entire drainage basin, especially when a combination of drainage structures is used. Or errors in storm sewer design that are insignificant in themselves, when multiplied, may become disastrous. Illustrating this possibility are the following paragraphs quoted in *Flood Problems in Santa Clara County* (County of Santa Clara Planning Commission, San Jose 13, California; 1952). They are offered not as criticism of engineering plans, but only to demonstrate the complexity of the problem of designing a storm drainage system for an expanding urban area and to point up the need for advance planning.

The correlation of drainage structures, storm water runoff and urban development must be considered. For example, a drainage plan developed in Los Angeles County to take care of floods of a 25 and 50 year rainfall frequency was found in 1950 to be only capable of taking care of floods on a two-year rainfall frequency. The winter of 1951-1952 really overtaxed this system. The Los Angeles County experience points out that their drainage system was underdesigned because of two misconceptions.

1. "Advancement in the sciences of hydrology and hydraulics shows that engineering text book and handbook data are often erroneous when applied to drainage structures.

2. "The speed, magnitude, character, and pattern of property developments were incorrectly appraised, and the hydrologic and hydraulic effects of these changes in land use were unforeseen."[3]

Trunk Storm Drains. Since a main trunk sewer should be designed to receive the runoff created by ultimate development in the drainage area it serves, estimates should be made of the extent of this future development. The following steps are suggestive only, and in no way reflect the amount of detailed engineering and statistical analysis that must be made before a plan is arrived at.

1. Determine boundaries and areas of watersheds. Figure 1, for Tacoma, Washington, illustrates an effective way of presenting this information.

2. Compile data on storm and flood frequency. This information is essential in order to determine design frequency for trunk storm drainage facilities. If a five-year storm interval is selected, storm sewers will operate at capacity once every five years. The bigger storm, which may occur only once every 10 years for instance will cause flooding because the storm drainage system, designed for a five-year storm, cannot handle it.

To determine what flood to design for is an exceedingly difficult problem, often requiring the advice of a hydrologist. The possible combinations of variables affecting runoff are great enough in number to make predictability an uncertain business. Local governments should be wary of any tendency toward pat applications of textbook formulas.

Nevertheless, a decision must be made on the storm interval for which the drainage system is to be planned and designed.

3. Map soil characteristics in the drainage basin. The Soil Conservation Service of the United States Department of Agriculture and state agricultural colleges have made soil surveys in nearly every state. The two maps composing Figures 2 and 3 illustrate the presentation of findings on a regional basis. Class I soil types in Figure 3 have good percolation characteristics; other classes descend in percolation characteristics to Class V, which is poor. Profile depth in each class is six feet. However, to calculate the rate of runoff, these data will be needed in considerably greater detail.

In the Tacoma study the drainage characteristics of surface soils within the metropolitan area were mapped on the basis of rapid, medium, slow and variable rates of drainage into soil.

According to the Brown and Caldwell survey of the Tacoma area,[4] selection of design frequency is governed by economic implications of local flooding; type, nature, and extent of area development that might be subject to damage by flooding; magnitude of applicable rainfall intensities; size or extent of tributary area; and economics of construction. This study recommends a 10-year design frequency for trunk storm drainage facilities in that particular area.

4. Estimate future growth and density of population within each drainage area. If a comprehensive plan of future development exists, it will be exceedingly useful at this stage. A map of present and projected population of watersheds within the Tacoma, Washington, area is shown as Figure 4. This service area is based on watershed and topographic boundaries and "is intended to include all of the area which will require public sewerage facilities in the next 50 or 60 years. It is established for planning purposes only."

5. Collect and map existing facilities and determine new trunk sewer construction needed. To adequately handle total runoff from tributary watersheds, several trunk lines may be necessary. In the Brown and Caldwell survey it was decided that the extent of trunk facilities should be limited to a minimum local service area of 160 acres.

[3]Statements within quotation marks are taken from an unpublished 1950 report of Charles H. Parker to the Los Angeles County Planning Commission and are quoted in the Santa Clara County study, which amplifies point number one by observations to the effect that drainage structures are generally treated as clear-water, uniform flow, fixed-stage flow structures. "None of these conceptions is true. . . . This means that the design of drainage structures is still in the formative stages. Until the variables in the mechanics and mathematics of silt, trash, and bed-load transportation are more perfectly appraised, the clear-water analysis must be used for design purposes. This approach will increase the potential of flooding when culverts and drainage channels are used to carry storm waters through urban areas."

[4]*Metropolitan Tacoma Sewerage and Drainage Survey*, Brown and Caldwell, Civil and Chemical Engineers, 66 Mint Street, San Francisco, California; 1957.

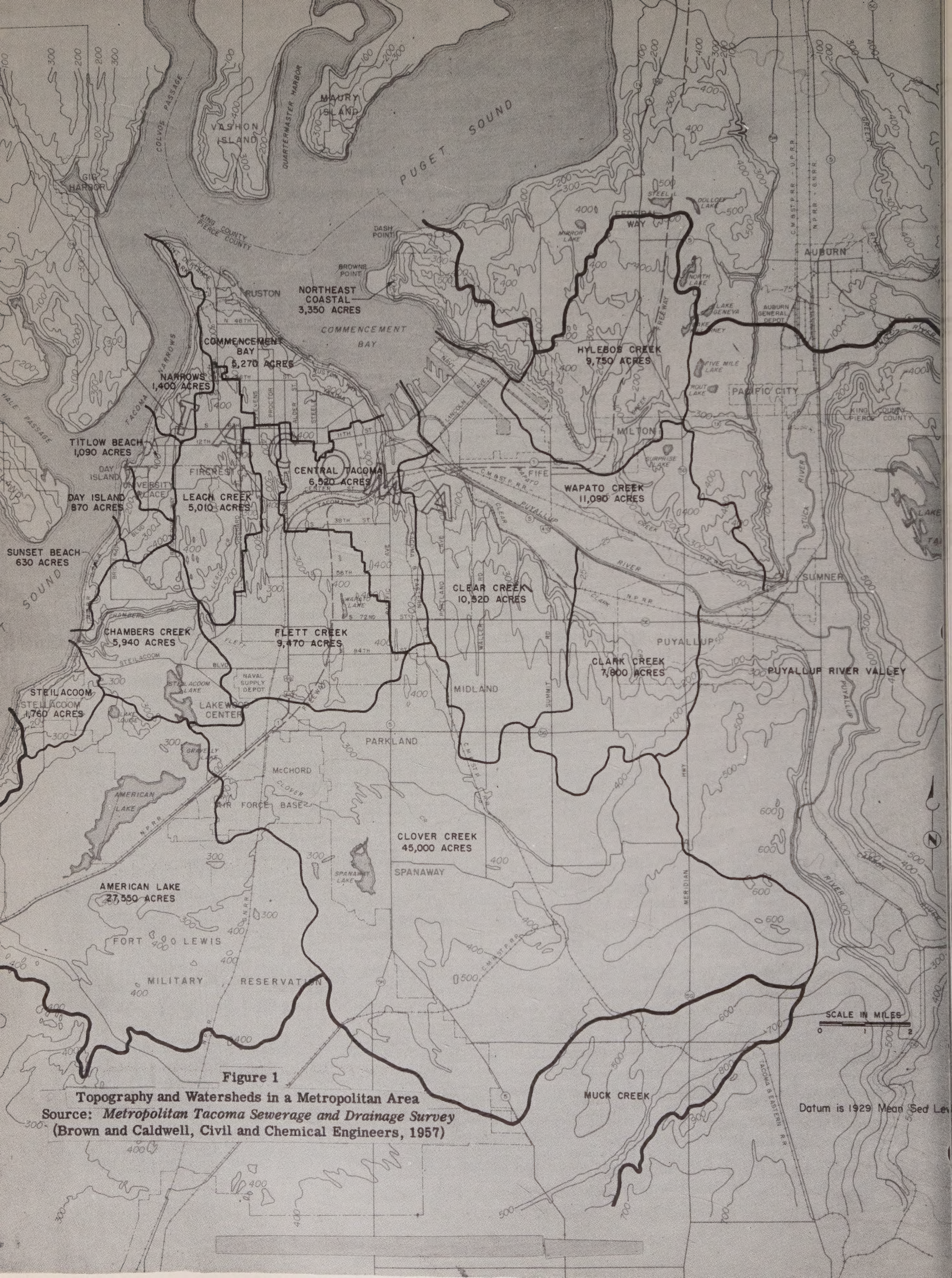


Figure 1

Topography and Watersheds in a Metropolitan Area

Source: ***Metropolitan Tacoma Sewerage and Drainage Survey***

(Brown and Caldwell, Civil and Chemical Engineers, 1957)

That is each trunk is laid into the tributary area to a point where not more than 160 acres is tributary to its upper end. Local service areas smaller than 160 acres may, of course, occur along the route of the trunk drain. From the standpoint of design, this results in a minimum trunk size in the range of 48 to 60 inches in diameter under conditions of minimum slope and average runoff.

6. Plan new trunk line construction needed both in built-up and new areas. Locations, relation to existing drainage facilities, and a schedule of recommended priorities should be indicated. If the public is to pay for any or all trunk line construction or is going to advance funds that will be reimbursed later, a financial program should be developed and expenditures included in the long-term capital improvement program.

After a survey of the type outlined above was made, the city of Davis, California submitted to the voters a "master drainage plan" for the city, which was coordinated with a plan for the unincorporated portion of the county in the drainage area. This plan and the issuance of general obligation bonds for the first stage of the drainage project were approved in a general election. Subsequently, a "precise drainage plan," based on the master plan, was adopted by ordinance under the method set forth in the Conservation and Planning Act of the state of California.

Local Storm Drains — Subdivision Control. If a master drainage plan has been developed, the determination of storm structures needed in any given subdivision is greatly facilitated. Under the scheme in effect in Davis, outlined above, new subdivisions are coordinated with the "precise drainage plan," which is divided into "drainage districts"[5] and shown on a map. All developments and improvements made within any drainage district established by the ordinance must conform to the requirements of the district as set forth. As subdividers develop individual areas they will know storm drainage requirements in advance and will be able to compute costs accurately.

A carefully worked out procedure for coordinating local subdivision development with a master storm drainage plan is an unusually advanced planning technique that may not yet be available to all jurisdictions. However, even if a master drainage plan is lacking, subdivision provisions can be drawn up that require developers to take care of the storm runoff created by their developments.

The subdivision regulations for Marple Township, Pennsylvania, for instance, specify that storm sewers provided to intercept storm water runoff along streets at intervals must be "reasonably related to the extent and grade of the area drained." To protect downstream properties, "special consideration shall be given to avoidance of problems which may arise from concentration of storm water runoff over adjacent properties."

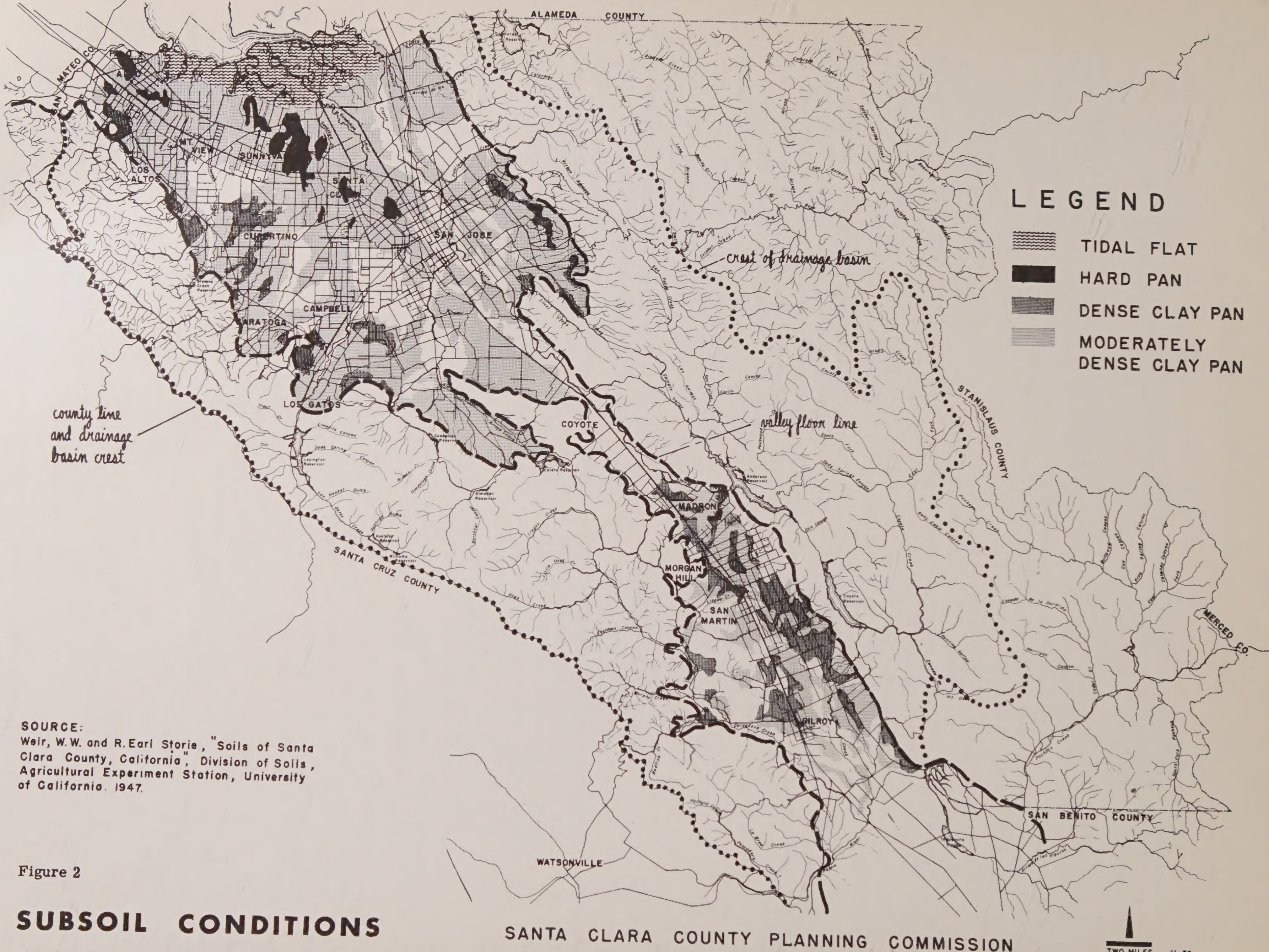
In Santa Barbara, California the developer is required to design drainage improvements according to the anticipated runoff from a 25-year frequency storm, "and calculations supporting said design shall be furnished as part of final plans." Other provisions in this ordinance reflect the public's interest in relating individual subdivisions to the watershed in which they are located.

Marin County, California also requires that all provisions for drainage and flood control be computed on the basis of 25-year frequency storms for maximum periods of intensity "for the entire drainage basin which the subdivision serves" and that they be made in accordance with the "improvement plan" that the subdivider submits. Bedford, New York requires that the drainage facility be large enough to accommodate runoff from a 50-year storm from its entire upstream drainage area.

In San Antonio, Texas the planning commission has published a booklet of recommended procedure for submitting subdivision plats. Among other things, the developer is asked to show the location of the subdivision within the entire watershed and to make calculations showing the anticipated storm water flow, including the watershed area. When a drainage ditch or storm sewer is proposed, it must be accompanied by calculations showing the basis for the design. The commission furnishes runoff data for different types of development including business as well as residential areas.

Related Storm Drainage Programs. Although storm sewers and flood control often are discussed separately, they are part and parcel of the same problem. It is impossible to say exactly where one leaves off and the other begins. And since urban development clearly creates the problem, the type and area of development are an integral part of the problem.

[5]This term has a special meaning within the context of the Davis ordinance. It does *not* mean a unit of government.



SOURCE:
Weir, W. W. and R. Earl Storie, "Soils of Santa Clara County, California", Division of Soils, Agricultural Experiment Station, University of California. 1947.

Figure 2

SUBSOIL CONDITIONS

SANTA CLARA COUNTY PLANNING COMMISSION

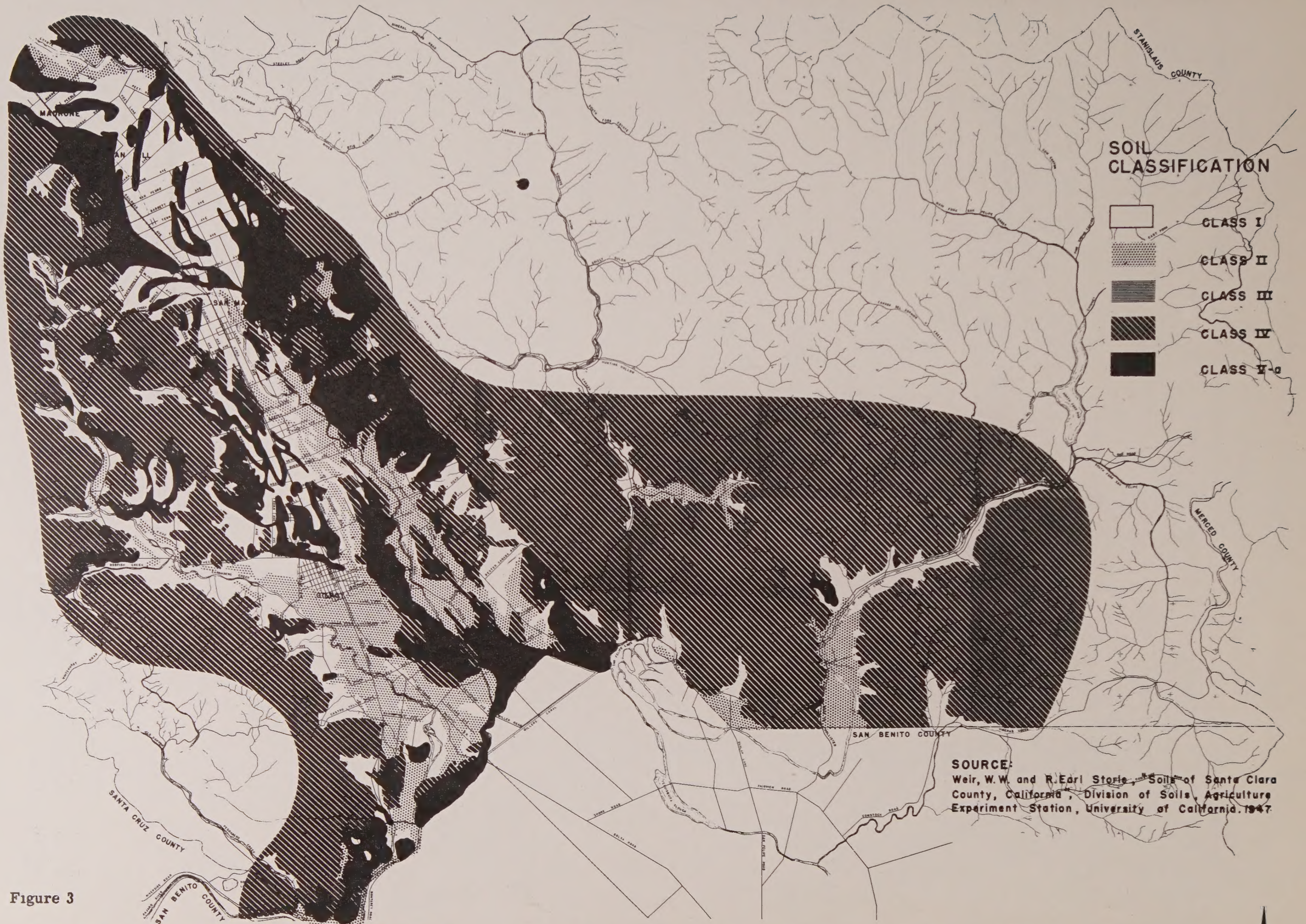


Figure 3

PERCOLATION CONTOURS SOUTH VALLEY, SANTA CLARA COUNTY PLANNING COMMISSION

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Figure 4
Present and Projected Population of Watersheds in a Metropolitan Area
Source: ***Metropolitan Tacoma Sewerage and Drainage Survey***
(Brown and Caldwell, Civil and Chemical Engineers, 1957)

Grading and filling the flood plain, straightening the channel, and building structures affect the carrying capacity of natural drainage channels as surely as real estate development affects surface runoff. Under a wisely drawn-up program other solutions will be taken into account in developing a plan for storm sewer construction. Clever and respectful use of the built-in drainage systems engineered by nature may in the long run result in a less costly storm sewer system and more effective control of floods.

1. Natural Watercourses. Creeks and headwaters that flow through new residential areas are subject to different degrees of control, depending on the authority granted to local governments by state platting acts. It is now all but universal practice to require that the location of natural watercourses be shown on preliminary and final plats. Many ordinances in addition specify that engineering data such as flood levels, width and direction of flow, and boundaries of the flood plain be supplied.

Also widespread is the authority to prohibit residential development in areas unsuited for that purpose. To build on lands subject to flooding is clearly impractical and potentially hazardous. Provisions embodying this prohibition are now common.

A relatively recent development is that which requires the subdivider to dedicate to the local government a strip of land of appropriate width on either side of the banks of a stream. In the district of West Vancouver, British Columbia, both the subdivision and zoning bylaws accomplish this dedication under the provincial statute governing subdivisions, which empowers the municipal engineer to require of the subdivider "suitable drainage facilities." To cushion the loss of land available for the subdivision, the size of lots adjoining the dedicated strips may be reduced.

In San Antonio, Texas an easement or right-of-way "conforming substantially to the limit of such watercourse, plus additional width to accommodate future needs" must be provided where a drainage way or natural channel or stream traverses a subdivision.

In addition to prohibiting encroachment on streams, it may be advisable to improve them by deepening and widening channels and removing debris and structures that obstruct flow. Straightening a channel is sometimes recommended, although its purpose is more often to utilize land economically than for flood protection.

A disadvantage of channel straightening is pointed out in the *Report of the Storm Water Drainage Study of the Inter-County Regional Planning Commission* (Denver, 1957), prepared by Dale H. Rea, consulting engineer. Channel straightening, the author says, reduces the length and width of the stream and volume of water it will hold. Reduced length increases slope and tends to speed the velocity of flow, resulting, in turn, in the concentration of large quantities of water. Consequently, this study recommends that flood storage reservoirs[6] be considered whenever storage capacity of streams is lost by filling or straightening.

Also recommended by the inter-county study are the following steps: public acquisition to title of all important natural drainage channels in the inter-county area; establishment of setback lines and grades for all open channels, whether publicly or privately owned; dedication of important natural open drains; and the establishment of a plan of development for each important drainage basin.

Related to the inter-county report is one prepared by the Denver planning office titled *A Storm Drainage System for Natural Gulch Areas – A Proposal for Gradual Engineering and Construction of a Natural Open-Park Drainage System in Denver's Four Critical Gulches* (1957). A beneficial side effect of this proposal, if adopted, would be the creation of parkways. The authors point out that strip parks are known to be more expensive to create and maintain than a consolidated park but that the extra cost is chargeable as part of the cost of a storm drainage system. Further, the report says, "the important fact is that the open-park drainage system is far cheaper than big underground plumbing of the same storm capacity, even including costs of removing existing houses, removing some existing streets, maintaining landscaping and maintaining engineering installations in

[6] See also section below on "Real Estate Developers," which describes the impounding areas supplied in Nassau County. Given proper location and design, impounding areas can be a relatively inexpensive facility.

the stream bottoms." These unusual proposals were made only after completion of engineering, legal, and financial investigations of feasibility.

Open natural drains — washes, gulches, arroyos, coulees — serve an essential function in the West where flash floods occur and where the steep grades of hills and mountains increase volume and rate of runoff. There, and in other parts of the country as well, they may be substituted for storm sewers in semi-rural areas. However, because of the dangers of contamination from septic tank effluents, which, in times of heavy rain, find their way into the ground water and thence into the open drain, open drains are undesirable in most residential sections that lack sanitary sewers.

2. Flood Plain Zoning. Though this important control can only be touched upon briefly here, it may be noted that it is closely related to the programs outlined above. Briefly, flood plain zoning regulates the type and density of use in the flood plain, preventing encroachment onto the floodway that would unduly increase flood heights and danger to life and property. Dwellings and outdoor storage of materials that would be damaged or likely to float away usually are prohibited in flood plain districts, as is any filling or construction unless approved by the proper public authorities.

3. Watershed Protection. To reduce runoff and to recharge underground water supply, some localities prohibit any type of urban building within certain portions of a watershed. For instance, the zoning ordinance of Arapahoe County, Colorado, has established a "forest conservation district" in which uses are limited to livestock grazing, fish hatcheries, recreational camps, growing of nursery stock, and related activities.

In Redlands, California, an "open land district" designation is placed on areas "beyond fire servicing where development might endanger life, property, or the watershed." Areas subject to inundation also are classed in this zone, as are public parks and flood control channels.

Special purpose zones such as these usually combine watershed protection with other purposes — recreation, forest and wildlife conservation, protection of scenery, and water storage reservoirs.

4. Street Improvements. Not to be overlooked is the street system that, in addition to being a channel for vehicular traffic, is also a conduit for water. Nearly every set of subdivision regulations, if it does nothing else, insists that lots be graded so as to drain into streets and that streets be graded and paved and curbs and gutters installed to handle the runoff resulting from low-intensity storms. Since the capacity of the street system to carry surface runoff affects the requirements for storm sewers, well designed gutters are a relatively inexpensive part of the storm drainage system.

Where topography permits, the street system should be designed as a supplementary storm drainage system. When existing streets are being surfaced and resurfaced in areas that lack adequate storm drains, an opportunity is created to combine the two programs in one operation. Street drainage and street improvements also should be coordinated in the long-range financial plan.

Governmental Organization

From planning and engineering points of view, storm drainage should be considered on a watershed basis. It is logical and in the long run more economical. Few cities, however, are so fortunately situated that storm drains can be planned and carried through entirely on the basis of work within the corporate limits. Depending on the nature of the city (central city, suburban city, or independent city), various proposals can be considered for governmental action on storm sewers.

These methods involve attempts to overcome the limitations of individual governmental jurisdictions through intergovernmental arrangements and area-wide approaches. They include annexation, city-county consolidation and separation, cooperative efforts between and among jurisdictions, strengthening county government, metropolitan federation, and special districts. The advantages and disadvantages of each of these methods have been explored thoroughly in other publications.[7]

[7] *The Future of Cities and Urban Redevelopment* (Chicago: University of Chicago Press, 1953), pp. 550-606. *The Government of Metropolitan Miami* (Chicago: Public Administration Service, 1954). *Special District Governments in the United States* (Berkeley: University of California Press, 1957). *The States and the Metropolitan Problem* (Chicago: Council of State Governments, 1956).

Special Districts. This method is singled out for further discussion because it is the one that has the greatest appeal to municipal and other government officials. It is the form of government most likely to be adopted where the storm drainage problems affect an area larger than a single jurisdiction. Special districts also have compelling financial advantages because they enable jurisdictions to circumvent tax and debt limits. Two of the larger and better known districts are the Metropolitan Sanitary District of Greater Chicago and the Metropolitan St. Louis Sewer District.

Michigan statutes provide for intergovernmental financing of storm drainage systems by assessment at large against benefited municipalities and other governments. The county drain commissioner can establish the assessment district for major storm sewers, either open or enclosed, upon petition of the benefited governments. Each participating governmental unit pays its share of the costs by an ad valorem tax which, for public health reasons, can be over and above any charter limits or even above the state constitutional limit of 15 mills. The drainage district is intended to serve the major and over-all needs of the area. Each participating government is expected to provide the storm sewer system within its corporate limits to serve local needs and to channel into the district system.

A number of local governments in southeastern Oakland County (Detroit area), Michigan, have joined to form the Twelve Towns Relief Drains. This governmental agency includes the cities of Berkley, Birmingham, Clawson, Ferndale, Hazel Park, Huntington Woods, Madison Heights, Oak Park, Pleasant Ridge, Royal Oak, Westwood, and Troy. The city of Southfield is expected to be incorporated and join at a later date. The Twelve Towns Relief Drains also includes Royal Oak and Troy Townships. In addition Oakland County and the state of Michigan are being assessed for part of the cost of the system for highway drainage and for a zoological park and golf course owned by the city of Detroit but outside the Detroit city limits. The latest tentative cost for the entire project is $44,092,000. The project is being held up by court litigation, but it is expected that actual construction can begin shortly.

Harper Woods and Grosse Pointe Woods, Michigan (near Detroit in Wayne County), have formed a drainage district under the same state law applicable to the Twelve Towns Relief Drains. This system also is being planned for a natural drainage area and happens almost to coincide with the corporate limits of the two cities.

A wide variety of special district laws are available in all states for the formation of storm sewer and drainage districts. Many of these laws, however, have been drafted primarily to serve the drainage needs of rural areas or for irrigation or other agricultural purposes.

Special districts always have the drawback of complicating an already involved local government structure and, too often, of not being directly responsible to the electorate served. At best, the special district is an expedient. It offers no long-range solution because it hinders the planning and financing needed for orderly growth and development. In most cases the special district is an expensive kind of government; its bonds often must pay a substantially higher rate of interest.

In some areas, in spite of these drawbacks, it still may be the only solution to providing storm sewers on a drainage area basis. Where possible, however, the solution should be sought through some type of metropolitan organization that is not limited to a single governmental function.

Financing Storm Sewers

The cities reporting for this survey have developed a variety of methods for financing storm sewers. Usually these methods have been developed in recognition of the fact that it often is not practical to assess the cost of all storm sewers against the community at large.

It should be pointed out, however, that persuasive arguments can be developed for general government financing of major storm sewers through direct municipal taxation, direct appropriations, or general obligation bonds. This is the concept that one authority has referred to as "community responsibility."[8] The author cites three reasons for his point of view:

[8] *Newsletter*, American Public Works Association, June, 1956.

1. Storm water originating on one piece of land and flowing off onto another is a waste product, must be disposed of, and the responsibility for such disposal can only rest with the person on whose land the water originates.

2. In improving any piece of property, the owner automatically increases the storm water runoff from his land by some 400 to 500 per cent and the responsibility thereby created is only too obvious.

3. The increased rate of runoff referred to above is actually a violation of the common law prohibition with respect to the concentration of outlaw water.

On the other hand most city managers and other municipal officials are well aware that the public often will not accept the reasoning of community responsibility. Of equal importance many cities have nowhere near the financial resources to finance a comprehensive storm drainage system. As one city manager put it in discussing the financial problem in his community, "My real impasse, I suppose, is one of money. If we could afford it, I probably wouldn't care."

Federal Aid. Federal aid for storm sewers is not directly available in the same way that federal grants are available for sewage treatment plants. Federal aid can be secured, however, under certain circumstances where storm sewers are developed as part of community planning programs, urban renewal projects, or flood control programs. The federal aid is given for a specific statutory purpose with storm sewers contributing to that purpose.

The federal government will pay two-thirds of the total net cost for an urban renewal project. The city government in meeting its one-third share can include public works and facilities that contribute directly to the benefit of the urban renewal area. These works and facilities can include streets, sanitary sewers, storm sewers, and other public improvements.

Another program that will provide a modest amount of aid is the program of advances for public works planning under the Housing and Home Finance Agency. The HHFA can advance federal funds as a noninterest bearing loan for the cost of preliminary investigation, surveys and engineering reports for public works that the municipality will construct with its own funds. The advances are repayable without interest when construction is undertaken.

Still another program is the public facility loans program, also under the Housing and Home Financing Agency, for loans to cities for the construction of public works, including water and sewer systems. Such loans are usually secured by general obligation bonds, revenue bonds, or both. The interest rate on 30-year general obligation bonds is 3.75 per cent and on 30-year revenue bonds, 4.25 per cent.

A few cities might qualify under the agricultural soil conservation program of the United States Soil Conservation Service. The intent of the law is to control flooding originating on agricultural lands. The cities of Boulder and Wray, Colorado, have received some federal aid under this law. Both cities qualify because their drainage problems are caused in part by runoff water affecting agricultural land either before or after damage to property within the city.

Another way, indirectly, that communities under 25,000 population can receive aid is through urban planning assistance grants administered by the Housing and Home Finance Agency. Under this program federal grants are made through official state planning agencies for planning assistance in cities under 25,000, up to one-half of the estimated cost. Such planning in smaller communities can include storm sewers.

Flood control projects under the Corps of Engineers of the United States Army can be constructed in or near cities when found to be economically justified and thus provide major benefits in the control of storm water. The project, however, must be for flood control, and the flood waters must originate largely or entirely outside the city.

Local Government Financing. A number of options are available for local government financing of storm sewers, not counting special assessments which are discussed below in a separate section. These local government options include the general property tax, direct appropriations from the general fund or from capital reserve funds, the use of gasoline taxes or other revenues shared by the state government, and general obligation bonds. All of these methods of financing are more

economical than other methods, particularly special assessments, and more nearly equal the concept of community responsibility in sharing the financial burden.

The extent of local government financing of storm sewers is indicated by data compiled for the 1958 *Municipal Year Book* for the section on "Municipal Debt Data." A total of 550 cities over 10,000 population issued one or more types of bonds in 1957 to finance public improvements. Of these 550 cities, 144 issued bonds specifically for storm sewers. One hundred and six cities issued general obligation bonds, 31 cities issued special assessment bonds, and seven cities issued revenue bonds.

Snyder, Texas (12,010), furnishes an example of a city that has financed storm drainage out of current city funds. The city is located at the fork of two normally dry streams which, over a period of years, had been overgrown with brush and had silted up with dirt and debris. The city and county jointly financed from current revenues the removal of a large quantity of dirt to widen and straighten the channels and to minimize the possibility of further flooding. The total project cost about $30,000, and the county government bore the larger part of the expenditure. In addition, in 1957, Snyder constructed a 42-inch storm sewer from current funds to intercept the fork of one of the streams. The storm sewer is sufficient to handle rains up to an intensity of two inches in 30 minutes. This project protects a portion of the central business district.

Two large cities are known to finance storm sewers either from current revenues or general obligation bonds. Philadelphia builds all of its storm sewers from general tax revenues. Cincinnati uses combined sewers and finances them usually from general tax revenues and general obligation bonds.

A few of the larger cities have issued general obligation bonds in sizable amounts for the construction of storm sewers. Voters in Phoenix, Arizona, on May 7, 1957, authorized a $70 million bond issue at a special election. The total amount included $24 million in general obligation bonds of which $14 million has been allocated to enlarge the sewer service area of the city from 33 square miles to 195 square miles. Part of this $14 million will be spent for storm sewers; one construction contract for $1.5 million is now under way.

Voters in San Antonio, Texas, recently approved $12 million in general obligation bonds for storm drainage. One-half of the amount is to be used for drainage throughout the city, and the remaining amount is to be used for coordinative drainage work with the San Antonio River Authority. The authority has begun a drainage and flood control program with expenditures planned for channel improvements and other projects in the metropolitan area amounting to $20 million. In addition, the city has adopted much more stringent subdivision regulations with storm drainage standards.

Beverly Hills, California (30,443), has completed a survey of the storm drain requirements for the city. The city recently secured voter approval for general obligation bonds totaling $4,250,000 for storm sewer construction.

<u>Real Estate Developers.</u> When storm sewers are needed principally or entirely for new subdivisions, the financing problem may be considerably simpler. There is ample precedent for requiring real estate subdividers to provide all public improvements and facilities needed to serve at least the immediate needs of the area. These improvements in many cities and counties include, as a minimum, streets, including street paving; curbs, gutters, and sidewalks; sanitary sewers; storm sewers; water lines; and street lighting.

Data compiled for the 1958 *Municipal Year Book* show that 692 cities over 10,000 population have comprehensive land subdivision regulations. Of these 692 cities, 443 require the installation of storm sewers in newly developed areas. Another survey, made in late 1955, by the Urban Land Institute,[9] showed that 71 out of 100 reporting cities over 50,000 population required the installation of storm sewers with the developer paying all of the cost. An additional seven cities required the developer to pay part of the cost. This study also showed that among 32 urban counties over 100,000 population, 27 required the developer to pay all of the cost for storm sewers, and two counties required the developer to pay part of the cost.

[9] *Utilities and Facilities for New Residential Development* (Washington, D. C.: Urban Land Institute, 1955).

An objection will be raised by subdividers if they feel that the requirements for storm sewers are greater than the sewers needed to serve the immediate area. Assuming the objection is valid, it can be met in several ways.

1. The city or county government can pay for the excess cost over the capacity of storm sewers needed to serve the subdivided area.

2. The city or county government can establish a revolving fund whereby the government initially pays for the excess capacity. As additional areas are developed and additional connections made to the storm sewer system, the city is reimbursed so that additional funds are available for storm sewers in other areas. The city government thus assumes the financial risk for further development of the drainage area.

3. A third method is to have the contractor pay for the excess capacity for storm water. Reimbursement is made to the developer as further connections are made to the system. Under this plan the developer is taking the financial risk for further development of the drainage area.

Three examples illustrate subdivision regulations for an urban county, a small city, and a large city.

The Nassau County, New York, subdivision regulations provide that developers pay for storm sewers. The county is located on Long Island adjacent to New York City. It includes two incorporated cities (Glen Cove and Long Beach), 63 villages, and Levittown, with 17,000 houses, comprising one of the largest unincorporated urban areas in the country. The county has experienced tremendous population growth in the past seven years and is now well over 1,000,000.

Subdividers are required to install all drainage systems together with streets and other public improvements. To guarantee performance, a subdivider is required to post a bond for the entire cost of all improvements; the bond is released only on acceptance of completed work.

Because of topographic and hydrologic factors, storm drainage is provided largely through basins or impounding areas which store water from storms and then replenish underground water supplies. Nassau County has more than 400 of these basins, the smallest of which is about 150 feet square and the largest 22 acres in area. The storm drainage basins have averaged about $20,000 each, excluding the cost of land. The county public works department estimates that in 10 years the county has obtained basins worth about $8 million.[10]

Davis, California (6,050), has a comprehensive planning program for storm drainage as described in a prior section of this report. From the standpoint of financing, the real estate developer is responsible for placing storm drainage facilities in any subdivision being developed within a drainage district. Where the drainage facilities must be placed to serve an area larger than that being developed, the developer pays a pro rata share of the cost on the basis of the area of the developed project to the total area of the drainage district. The pro rata share is determined by the director of public works. The city underwrites the balance of the cost and, in turn, collects from other subdividers as subsequent developments are made within the drainage district. Each "precise drainage plan" is provided for by ordinance.

For new subdivisions in Fort Worth, Texas, the developer pays for all of the cost of storm sewers, with partial reimbursement on the basis of a specific contract drawn up between the city and the developer for each project. The developer pays for all trunks and laterals and is reimbursed for the cost of the trunk lines when he has completed houses on 51 per cent of the lots in the blocks adjacent to the trunk lines. The developer constructs all necessary laterals at his own expense.

Financing by Property Owners. In older sections of the city that have inadequate or nonexistent storm sewers, the special assessment method of financing has much to commend it. The city government probably will feel that it cannot spend tax funds or bond revenues on improvements in older sections of the city when subdividers (which means ultimately the home buyers and other property owners) must bear the cost in newly developed areas.

[10] Information taken from article in *Engineering News-Record*, October 3, 1957, pp. 30-31, 33-34, and 37.

The usual front-foot method, which is used for the great majority of special assessment projects for streets and water lines, is not as suitable for storm sewers. While it does have the advantage of being simple and easy to understand, it falls short from the standpoint of equity when compared to an area or square-foot method of assessment. The front-foot method does not take into account the contribution of runoff water from properties farther away from the improvement but still in the natural drainage area.

In Miami, Florida, storm sewer districts are created by city ordinance, with boundaries established by natural watershed areas. The city government bears one-third of the total cost for storm sewers in each district. The remaining cost is assessed against the benefited owners on a square-foot basis. In some cases an agreement is entered into between the property owners and the Miami Department of Public Services. The property owners pay the cost of materials, and the city department performs the work with force account labor. For newly developed areas, city ordinances require a performance bond and minimum improvements, including storm drainage.

Special assessments were recommended for the major part of financing storm sewers for Englewood, Colorado (16,869). A report by the planning and traffic director prepared in 1956 provided for the following steps in the establishment and financing of storm sewers for Englewood:

1. Establish municipal policy by ordinance for financing storm sewers by special assessment.

2. Carry on a public information program and campaign to explain the new policy to the general public.

3. Apply for federal aid under the urban renewal program where storm sewers can be used to meet part of the one-third share of the cost.

4. Authorize detailed engineering studies for the plan. The report proposes one storm sewer district to coincide with the city limits and a series of subdistricts within the city. The large district would pay for the outfall sewer trunks to carry the bulk of the water from the entire city. These would be financed by the city at large through general taxation or general obligation bonds.

5. Take appropriate steps to form the large district and the subdistricts.

6. Assign priorities for storm sewers to subdistricts. Storm sewers would be built in the subdistricts over a period of time with specific amounts budgeted each year. Storm sewers would be financed in the subdistricts by special assessments on a square-foot basis.

The recommendations on financing storm sewers for Englewood have been held in abèyance for the following reasons: (1) In the judgment of city officials the original engineering plan was too expensive and was overdesigned for the city's needs. (2) The city is now drawing up its first comprehensive plan which will include a subplan for drainage parkways. (3) The city also is drafting its first home-rule charter which probably will provide better methods of assessing the costs of storm sewers than is now permitted by state statutes.

Clearwater, Florida (15,581), adopted a subdivision ordinance in 1953 providing that the real estate developer must pay for all storm drains in new subdivisions. Special assessments are used, however, for older sections of the city that lack storm sewers. Two methods of assessment are used— front-foot and area. The front-foot method of assessment is used where a small number of properties is directly benefited and where front footage clearly is in proportion to area. This usually applies to a few houses or one specific street where the drainage problem is strictly local in character.

The area method is used in Clearwater for larger projects or to overcome the difficulty of the front-foot assessment where irregular lots are involved, some of them having a small frontage on the street. Occasionally the city government will participate in the cost for correcting drainage conditions applying to individual lots. Usually this applies to drainage problems caused by driveways or low lots on individual properties. The city furnishes engineering and labor, and the property owner pays for all materials.

Utility charges are another way of charging property owners for the cost of storm sewers. Vancouver, Washington (41,664), has adopted a plan of pay-as-you-go financing for storm sewers

from water utility revenues. In 1956 a citizens' committee of 20 members was appointed to study the six-year capital improvement program for the city government. Among other subjects, the committee studied the storm drain problem and recommended than an ordinance be passed adding a charge to the water bill for the building of storm sewers on a pay-as-you-go basis. The ordinance was adopted, and the surcharge on the water bill brings in about $100,000 per year.

While the Vancouver plan has the obvious advantage of bringing in the money, it is not equitable because water usage bears no relationship to storm sewers. The water bill serves only as a convenient collection device. Financially, storm sewers are not utilities because charges cannot be calculated in relation to usage and benefit.

Utility-type charges would be more acceptable with an assessment based on lot area or even a flat rate.

A variation of the utility method would be to finance the construction of storm sewers from the proceeds of revenue bonds secured by the earnings of the entire sewerage system. The simplest way to guarantee the revenue bonds is to add a stated amount to the water bill to cover all sewerage services (sanitary and storm). Sewage service charges, for sanitary sewer systems, have been adopted in many cities. It is easy to extend this idea to the utility financing of storm sewers.

Combination of Methods. This report has stressed the difficult problem of deciding which of the interested parties bears the cost of storm sewers — the city government, the real estate subdivider, or the property owner. In working this out in many cities, two or more financing methods probably will be needed depending upon the area of the city involved, the degree of residential and industrial development, and the availability of city funds.

One example is furnished in a report prepared by City Manager D. G. Weiford for the city council of Eau Claire, Wisconsin, and submitted in June, 1957. After reviewing the over-all financial problem the report is divided into three principle sections: old areas, new areas, and transitional areas.

The old areas of Eau Claire are served in part by storm sewers which have been paid for in the past from general city funds. The report suggested that this method be continued, subject to the availability of general city funds.

It was recommended that subdivision regulations provide that the developer pay the cost of storm sewers in new areas. Separate financing procedures are proposed so that the subdivider does not take the financial risk for the installation of storm sewers beyond the capacity required for the immediate area he is developing. The city would finance the excess storm sewer capacity needed with reimbursement from other developers as further development takes place in the area.

The transitional areas are sections of Eau Claire which have been platted but where relatively little development has taken place. Because the plats have already been recorded the city has no way of compelling the developer to pay for storm sewers. The proposal is made that the city government negotiate with the owner or owners on the financing of storm sewers as these areas are developed in an attempt to obtain a cash outlay for sewer construction. If negotiations fail, the only alternative would be to assess the cost against the benefited property under special assessment procedures.

Conclusions

For effective and long-term results, storm drainage must be considered on a natural watershed basis. Some cities are fortunate enough to be in a position where storm drainage problems, in a planning and engineering sense, can be confined largely or entirely within the city limits. For most cities this will not be the case. For the latter group of cities some method should be evolved of working with other governmental units on three major phases of the storm sewer problem: area-wide planning, governmental organization, and financing.

In some localities consideration should be given to the assumption of county-wide services by the county government. Where a type of metropolitan program exists, the solution is greatly simplified. Either way the responsibility is vested in a governmental unit that serves the entire area,

has the greatest financial resources, and can exercise the authority that is needed for area-wide problems.

Short of the area-wide, multi-purpose government, the special district has wide appeal. It is easy to set up and finance. In the long run, however, the special district is likely to be detrimental to coordinated land development and to result in uneconomic overlapping of single-purpose authorities.

Planning for storm sewers should begin with the watershed or drainage area. It should be done so that future growth is anticipated and proper facilities installed. Development is likely to begin with the small drainage system serving one housing development. Unless provision is made for future development, however, the drainage system will soon be inadequate.

While cities and even counties cannot control an entire watershed, they can draft and enforce subdivision regulations to control development in the near future and to provide adequate drainage. This includes not only provision of storm sewers but also protection and improvement of natural watercourses and street standards providing for runoff and drainage.

No formula or method can be recommended generally for financing storm sewers (except for new subdivisions). General government financing has a great deal of appeal as a "community responsibility," but it simply cannot be sold in many communities. Special assessments pose problems because of the difficulty of convincing property owners that land area is related to benefit. Other financing methods have equally serious objections.

If the problem is one more of flood control than of storm drainage, the city government is justified in using its own fiscal resources either from general revenues or from general obligation bonds. Sometimes, indirectly, federal and state aid is available for flood control in outside areas which, in turn, benefits the community.

If the city has no storm sewers at all, the city has at least three alternatives. First, the city government can pay for the storm sewers for the entire community from current revenues, general obligation bonds, or a combination of the two. Very few cities, however, have the financial resources for such a program. If they did, they would be much more inclined to use the money for other public improvements. Second, a utility charge can be added to the water bill to finance storm sewers either on a pay-as-you-go basis or through the issuance of revenue bonds. Third, special assessments can be used with properties assessed on an area basis for the entire drainage area.

If the problem is one only of storm sewers in new subdivisions, then the answer definitely lies in the adoption or amendment of subdivision regulations to provide for the installation of storm sewers by the real estate developers. The experience of hundreds of cities in the last decade has shown that storm sewers are just as essential as sanitary sewers, streets, sidewalks, and other improvements. Because land subdivision and development create the immediate need for storm sewers, the cost of all trunks and drainage structures to serve that subdivision should be borne by the developer.

If the new trunk sewer is needed to receive the discharge from local storm sewers within the subdivision, the responsibility for bearing the cost is less clear-cut. However, on the basis of engineering and economic studies, the extent of runoff contributed by any one subdivision within a watershed can be determined and costs allocated so that the developer pays only that percentage of the cost of a trunk line that is directly attributable to the area he has developed.

Financing can be accomplished in one of two ways. Either the city (or county) government or the subdivider pays the difference between the total cost and the costs allocable to the particular subdivision. In either case the interested party is reimbursed as further areas are developed. While this involves an element of speculation, it holds the financial risk to the absolute minimum. The loss is limited only to the extent that the entire drainage area is not developed.

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